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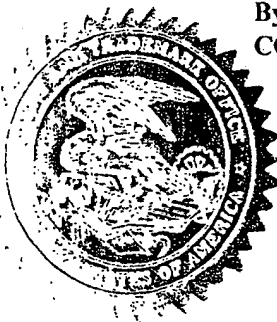
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APPLICATION NUMBER: 60/138,060
FILING DATE: June 08, 1999
PCT APPLICATION NUMBER: PCT/US00/15603

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Docket Number: 0111637/001

R/PROV

PROVISIONAL APPLICATION FOR PATENT COVER SHEET (Large Entity)

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

INVENTOR(S)/APPLICANT(S)					
Given Name (first and middle (if any))	Family Name or Surname	Residence (City and either State or Foreign Country)			
Brian T. Andreas H. Cory	McGeer von Flotow Roeseler	Underwood, Washington Hood River, Oregon. Hood River, Oregon			
<input type="checkbox"/> Additional inventors are being named on page 2 attached hereto					
TITLE OF THE INVENTION (280 characters max)					
METHOD FOR RETRIEVING A FIXED-WING AIRCRAFT WITHOUT A RUNWAY					
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Country	US	Telephone	312-372-1121	Fax	312-372-2098
ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification	Number of Pages	4			
<input checked="" type="checkbox"/> Drawing(s)	Number of Sheets	9			
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
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<input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: _____					

Respectfully submitted,

SIGNATURE

DATE

June 8, 1999

TYPED or PRINTED NAME

Dante J. Picciano

REGISTRATION NO.
(if appropriate)

33,543

TELEPHONE

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET (Large Entity)

INVENTOR(S)/APPLICANT(S)		
Given Name (first and middle [if any])	Family Name or Surname	Residence (city and either State or Foreign Country)

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Patent Application of
Brian T. McGeer, Andreas H. von Flotow, and Cory Roeseler
for
**METHOD FOR RETRIEVING
A FIXED-WING AIRCRAFT WITHOUT A RUNWAY**

BACKGROUND OF THE INVENTION**1. Field of the Invention**

This invention addresses the problem of landing a small fixed-wing aircraft aboard a ship or in an otherwise confined space offering insufficient room for a runway (for example the roof of a building). The method involves the aircraft engaging a cable or cables held aloft by a kite, balloon, or kite/balloon hybrid. The aircraft is decelerated by the cable and then lowered to the ship.

2. Description of the Prior Art

Operation of small unmanned aircraft often calls for retrieval where space is insufficient for a normal landing run, e.g. aboard a boat. Current methods require the aircraft to fly into a net (e.g. US patents 4,056,247; 4,143,840; 4,456,205; 4,979,701; 5,109,788) or to deploy a parachute (e.g. US patents 3,980,259; 4,311,290). Net techniques have disadvantages including: (1) difficulty of precise targeting, especially when the approach is through the turbulent wake of a ship's superstructure or when the ship is rocking, with associated high risk of damage if the aircraft enters the net incorrectly; (2) significant risk of damage even when the net entry is correct; (3) hazard to staff and equipment aboard ship; (4) complexity and cost of the net and associated apparatus; and (5) requirement for a large deck space. Parachute techniques have disadvantages including: (1) weight and complexity of equipment aboard the aircraft; and (2) difficulty of precise landing, and associated risk of damage.

3. Objects and Advantages

The object of the present invention is to improve upon current techniques in the following respects:

1. Easier targeting;
2. Less risk of damage to the aircraft if the target is missed;
3. Reduced hazard to staff and equipment on the surface;
4. Simpler apparatus, with lower cost and easier assembly and dismantling;
5. Smaller requirement for deck space, with associated feasibility of use even on small boats.

These improvements are realised through a combination of two distinct and novel concepts:

1. Use of a balloon or kite to suspend the retrieval apparatus; and
2. Use of a vertical cable to engage the aircraft.

Application of each concept by itself would be novel and effective, but the greatest advantage over current techniques is realised by using the two in combination. The techniques are particularly applicable to small aircraft, *i.e.* weighing not more than a few tens of kilograms, since the size of the apparatus then becomes quite practical for routine use.

SUMMARY OF THE INVENTION

This invention calls for a kite or balloon to hold aloft one or more cables, the lift force on each cable being sufficient also to support the aircraft to be retrieved. The cable could be the kite's tether, or a separate line also suspended by the kite. The aircraft flies into the cable such that contact is made on the wing leading edge or other spanwise surface. As the aircraft moves forward against the cable, the contact force causes the aircraft to decelerate and yaw toward the cable; the cable then moves spanwise on the aircraft until it encounters one of a number of hooks. Each hook has a spring catch or like mechanism such that the cable is captured and will not subsequently be released until the aircraft is retrieved. After the cable is thus captured, the aircraft continues to decelerate until it no longer has flying speed. Retrieval can then be effected by sliding the aircraft down the cable, or by lowering the cable itself.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention will more fully be understood with reference to the attached drawings of example embodiments, in which

FIG. 1 is a diagrammatic side view of the kite and tether;

FIG. 2 is a diagrammatic side view of an alternative embodiment, in which the capture cable is separate from the kite tether;

FIG. 3 is a diagrammatic plane view of the wing of the aircraft, including hooks for capturing the cable;

FIG. 4 is a diagrammatic isometric view of a capture hook;

FIG. 5 is a diagrammatic plane view of a capture hook;

FIG. 6 is a diagrammatic top view of the aircraft and cable during recovery;

FIG. 7 is a diagrammatic side view of the aircraft and cable during recovery;

FIG. 8 is a diagrammatic isometric view of an embodiment in which kites support a net, rather than a generally-vertical cable;

FIG. 9 is a diagrammatic isometric view of an embodiment in which a generally-vertical cable is supported by a derrick rather than a kite or balloon.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a side view of a kite 1 anchored by its tether 2 to a boat 3, the tether 2 optionally being fitted with stops 4 at intervals along its length to prevent the aircraft 5 from sliding freely to the bottom of the tether 2 during capture.

FIG. 2 shows a variation on the concept in which the kite 1 suspends a second cable 6 tensioned by a weight 7 (or alternatively by a sea anchor). This arrangement has the advantage that whereas the lift force generated by the kite 1, and therefore the tension in its tether 2, must be greater than the weight of the aircraft 5, that in the second cable 6 can be smaller. The decelerating force on the aircraft 5 scales with the ratio of cable tension to cable length. Hence if

ne apparatus is sized for a predetermined maximum deceleration, the possibility of making the tension in the second cable 6 relatively low allows the kite tether 2 to be made shorter in the embodiment of FIG. 2 than in that of FIG. 1. A second advantage of the embodiment in FIG. 2 is that after capture the aircraft 5 can be brought aboard the boat 3 by reeling in a drawstring 10 while lengthening the suspending cable 6, for example by paying cable 9 up the kite tether 2 and over a pulley 8 attached to the kite 1. In the embodiment of FIG. 1, on the other hand, the aircraft 5 is retrieved by lowering the kite 1.

FIG. 3 shows the upper surface of a wing 11 designed to intercept a suspended cable 13. Any number of capture hooks could be placed along the wing leading edge 18. In this embodiment only two such hooks 12 are built into the leading edges at the wing tips.

FIGS. 4 and 5 show the wingtip hook installation in more detail. Shortly after the wing makes contact, the cable 15 in FIG. 5 will slide outward along the leading edge 18. Upon reaching the wingtip it will push a gate from the closed position 14 into the open position 17, and so move past the gate 16 and into a tapered slot 19. As it cable continues into the slot it will become clamped 13. Meanwhile the gate 14 will have returned to the closed position so that the cable cannot escape. (To reduce aerodynamic drag of the hook prior to recovery, the slot 19 might be sealed with tape of sufficiently light weight that the cable 16 can tear through it during capture.)

Many different designs could be used for the hook. Its essential function is to capture the cable 13 and prevent subsequent escape. The hook can be designed to capture the cable firmly and so prevent sliding, or alternatively to permit sliding. If the hook allows sliding then the aircraft 5 can be brought down to the boat 3 in FIG. 1 without lowering the kite 1 itself.

FIGS. 6 and 7 shows stages in an example deceleration sequence. At first contact the aircraft 20 strikes the cable 26 at a point near the wing root 22. (The aircraft in this example has a pusher propellor 23 and inverted-vee tail 24 mounted on twin tailbooms 25.) After contact the aircraft begins to yaw, roll, and descend, while the cable slides outward along the wing leading edge, the aircraft and cable reaching the positions marked 27 and 28 respectively at the moment of capture in a hook at the wing tip. The yaw and roll then increase, and for most of the subsequent deceleration the attitude of the aircraft is comparable to that in position 29. At low speed the aircraft drops below the cable 30, until finally it is left dangling in the wind. The aircraft can then be lowered slowly to the boat.

FIG. 8 illustrates use of two kites 31, 32 to suspend a retrieval apparatus different from a vertical cable, in this case a net 33. The kites are rigged to pull their tethers 34, 35 outward as well as upward. The net mesh is sized such that the adjacent tapes (e.g. 36, 37) push against the fuselage of the aircraft 38 as the fuselage enters the net, and each tape is snagged by a barb on the fuselage. The aircraft can then be retrieved by lowering the kites. While a net is more complicated to handle than a vertical cables, it has the advantage of reducing spanwise loading on the wing during deceleration.

FIG. 9 illustrates suspension of a vertical cable 39 by a derrick 40 rather than by a kite or balloon. The derrick 40 holds the cable 39 clear of the side of a ship 41, and the cable 39 is tensioned by a weight 42 (or alternatively by a sea anchor). The aircraft 43 strikes the cable 39

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as in FIGS. 6, 7, then captures the cable in a hook on its wing, and decelerates 44. Targeting may be somewhat more difficult with the embodiment of FIG. 9 than with that of FIGS. 1 or 2, since in practical implementations a derrick will not be as high as a kite. However retrieval aboard the ship will be simpler with the embodiment of FIG. 9.

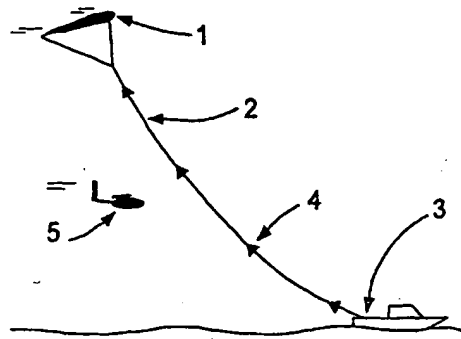
CLAIMS

We claim

1. A method for retrieving a small aircraft onto a ship or other confined space (such as the roof of a building) wherein the arresting gear consisting of a net or one or more cables is suspended by one or more kites or balloons;
2. An arresting gear consisting of one or more cables whose orientation is generally vertical, which contact the wing leading edge or other spanwise-oriented member on the aircraft, and then slide along the spanwise member to be captured in one of an array of hooks.

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FIG. 1



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FIG.3

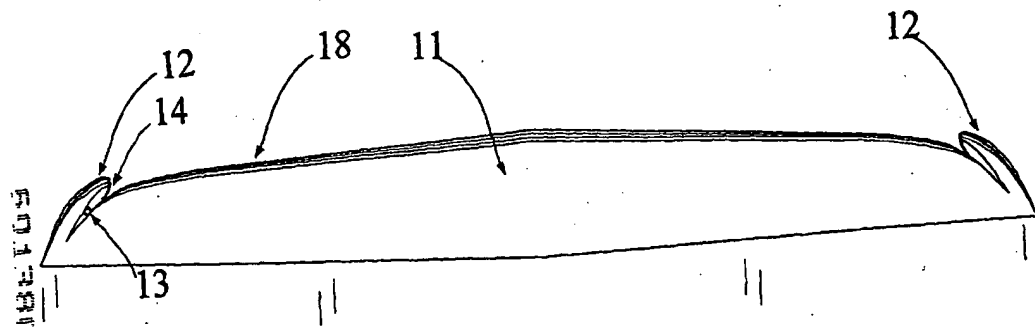


FIG.4

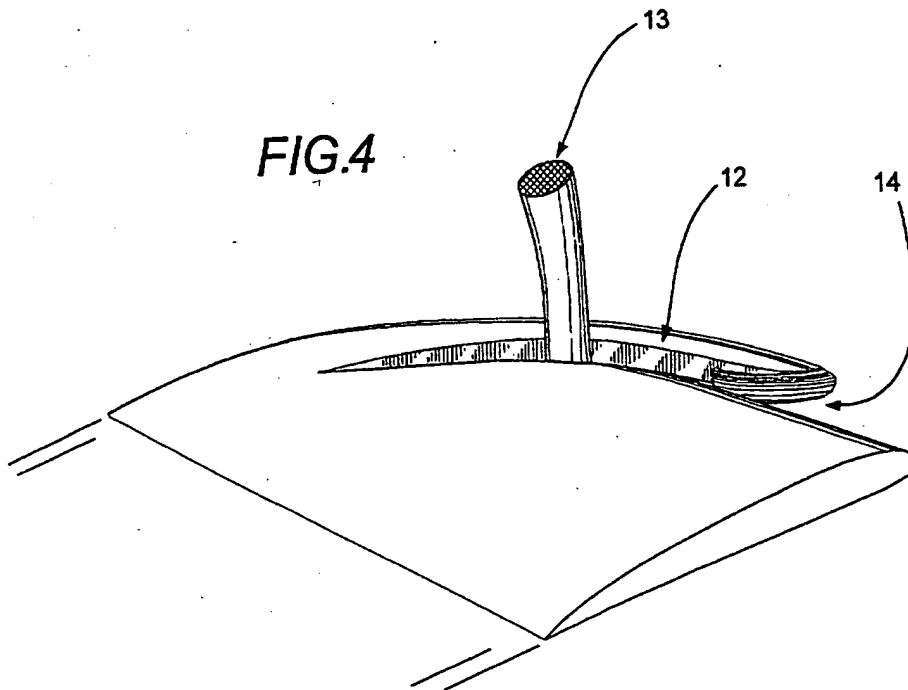
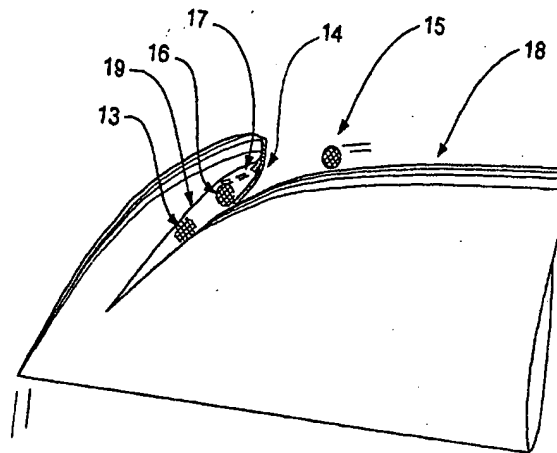
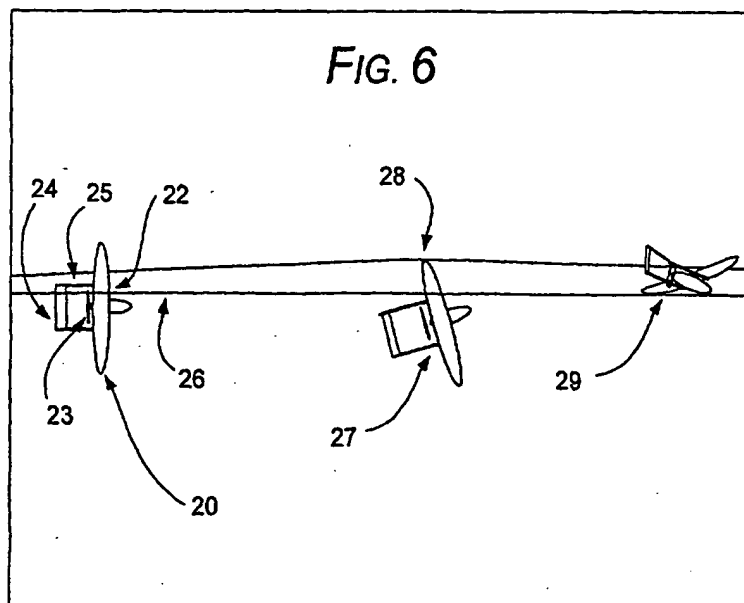


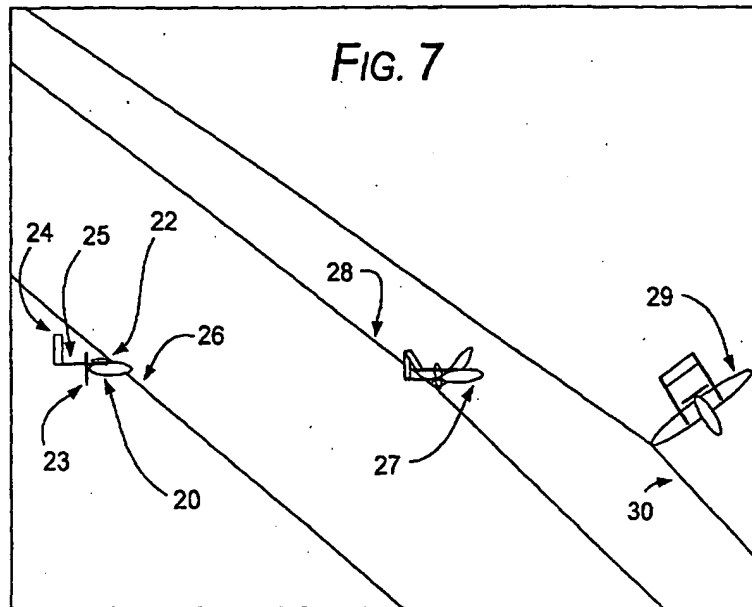
FIG.5



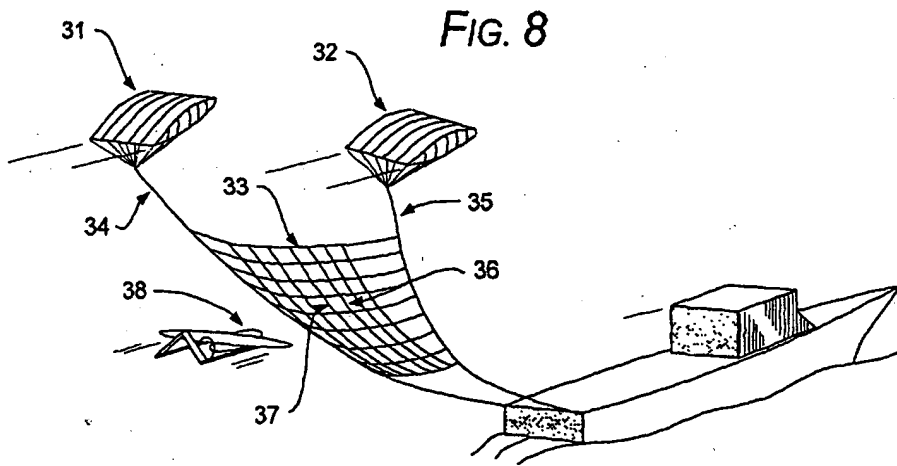
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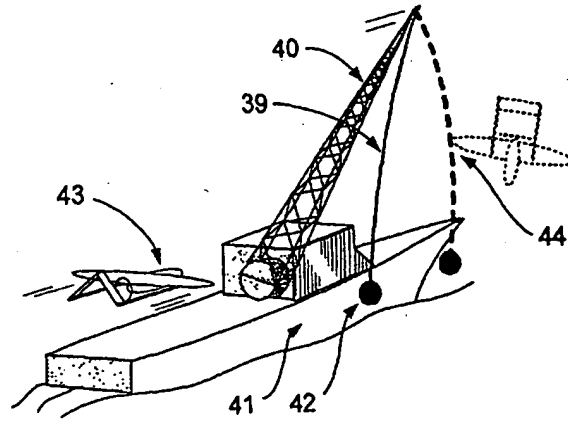


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FIG. 9



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